4.4 Data Used in the Development of EMFAC2000

Several data sets were available for use in developing EMFAC2000:

1. The data used in the development of the original CALIMFAC model, consisting of ARB data up to Surveillance set 9, augmented by vehicles from early I&M data sets to adjust the component malperformance rates.
2. New ARB data from studies 2S88C1, 2S89C1, 2S89C2, 2S91C1, and 2S91C2.
3. New ARB data from I&M evaluation studies.
4. EPA data obtained at Hammond and Ann Arbor to develop correlations between IM240 and FTP results.

This section discusses the selection of particular data sets to be used in the determination of EMFAC2000 regime and emission rate information and the quality control procedures used on the data. Data sets were selected in consultation with CARB staff. The goal was to obtain representative data sets, which would have a sufficient number of vehicles to give statistical significance. Data sets obtained in studies of I&M programs contained only vehicles which were expected to fail the I&M program. Such data sets were not considered representative of the entire fleet and were not used (with some exceptions noted below) in CALIMFAC or EMFAC2000. One important restriction was placed on the data used to determine regime growth functions in the absence of an I&M program. Only data on vehicles which had never been through an I&M program could be used for this purpose.

4.4.1 ARB Data

The data previously used to develop the CALIMFAC model contained results from CARB surveillance and high-mileage tests up to and including Surveillance 9 (2S87C1). That data set used selected data from the original 1987 study of the California I&M program to provide a data set that was representative of actual vehicle malperformance rates. This was done by adding vehicles from the I&M data set to match vehicle component malperformance rates from the BAR random roadside tests. This entire data set, referred to as the old master data set, was used in the development of CALIMFAC and was used again for EMFAC2000. For both CALIMFAC and EMFAC2000 this data set was assumed to have vehicles which had not been through an I&M program. These data were used in the development of regime boundaries, regime emission rates, and regime growth functions. The vehicles in the Surveillance 9 data set had actually been through the initial biennial I&M program in California, but the effects of this single program step were assumed to have a negligible impact on the distribution of vehicles among regimes.

Recent surveillance and high-mileage data studies by ARB (2S88C1, 2S89C1, 2S89C2, 2S91C1 and 2S91C2) were done on vehicles that had been through one or more I&M cycles. These data were used to develop the definition of regime boundaries, because the same regime boundaries are applied in the model to both I&M and non-I&M vehicles.

However, these data could not be used to determine the regime growth functions[*] in the absence of I&M. Development of these functions is discussed in the next section.

4.4.2 Quality Control Checks with ARB Data

The following series of quality control checks were used on the new CARB data sets:

- The weighted FTP emission rates were calculated from individual bag data and compared to the weighted FTP emission value in the data set.
- The model year and emission standard fields were checked to ensure that the emission standards were appropriate for the model year.
- The reference table developed for the California Bureau of Automotive Repair (BAR) was used to check the description of the vehicle emission control system.

Details of the discrepancies found in these quality control checks were sent to CARB staff and the appropriate corrections were made in the database.

4.4.3 Comparison of Malperformance Rates in ARB and BAR Data

An important measure of the representativeness of the data set is the observed occurrence of vehicles with emission control components that are not functioning properly. The BAR maintains a random roadside survey, which stops vehicles on the road and observes the performance of emission control components. The malperformance rates for the ARB surveillance data were compared to those from the BAR random roadside surveys. Two separate sets of vehicles were examined: (1) gasoline-powered, California-certified passenger cars; and (2) all vehicles in the data set. Details on this comparison are provided below.

4.4.3.1 Analysis of ARB Data

Two files from the CARB data set were used in the analysis. The vehicle description (VEHDESC) file contained basic information about the vehicle the diagnostic and repair code (DRCODE) file contained information on malperforming components.[*] The first step in the analysis was to determine the particular emission control components that should be present on a given vehicle. That information was taken from specific fields in the ARB data set shown in Table 4-17. The specific codes used to identify system components in the DRCODE file were taken from an ARB analysis.[**] These also are shown in Table 4-17.

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[*]This is the name of the regression equations giving the population of the various regimes as a function of some parameter (typically vehicle age and/or odometer reading).

[**] Preliminary draft memo from Dilip Patel to Mark Carlock at ARB, "Analysis of 2S88C1, 2S89C1, 2S89C2 and 2S91C1/C2 programs," received at Sierra Research on December 20, 1993. Final results are presented in Table 2 of that memo.

Table 4-17 Identification of Components		
Emission Control System	System Component Codes	Presence of Emission Control System Determined by
Exhaust Gas Recirculation (EGR)	600, 606, 608	Variable EGR in VEHDESC file equal to 'Y'
Spark Ignition System	306, 309, 314	Assumed to be present on all vehicles
Evaporative Controls	406, 408, 409, 410	Assumed to be present on all vehicles
Thermostatic Air Cleaner	206, 208, 209, 211	Assumed to be present on all vehicles
Positive Crankcase Ventilation (PCV)	506, 508	Assumed to be present on all vehicles
Air Injection System	700 to 799	Variable AIR_INJ in VEHDESC file equal to 'A' or 'P'
Catalyst	811	Variable REACTOR in VEHDESC file equal to 'C', 'T', 'D', 'O', or 'E'
Oxygen Sensor	813	Variable O2_SENS in VEHDESC file equal to 'Y'

Records in the DRCODE file contain fields that identify the vehicle and system component and contain a one-character diagnostic code (DICODE) and a yes/no flag to indicate tampering (TAMPER). A malperforming vehicle is recognized when the tamper flag indicates yes or when a malperforming part is indicated by one of the following values in the DICODE field: plugged (‘B’), disconnected (‘D’), electrical defect (‘E’), defective (‘F’), leaking (‘L’), missing (‘M’), off specification (‘O’), or misrouted (‘R’). Records in the DRCODE file also have a diagnostic and repair sequence (DR_SEQ) field that identifies a particular test in a sequence of tests. Malperformance for a given vehicle and system component may be noted at any value of DR_SEQ. If none of these conditions were met, or if none of the component codes for a particular system were listed in the DRCODE file, it was assumed the system was performing properly.

The malperformance analysis for a particular system identified in Table 14-17 examined all the component codes corresponding to the system. If any of the component codes for a given system indicated malperformance, then the system was classified as malperforming. (For example, evaporative system malperformance would be detected by a tamper flag set to yes, or a DICODE value indicating malperformance, for system

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[***] Vehicle 380 in project 2S89C2, a 1989 Toyota P/U LB, had a 'W' in the O2_SENS field. It was assumed the vehicle had an O_2 sensor, as did the other vehicle in the same engine family.

components 406, 408, 409, or 410.) No distinction was made between tampering and other malperformance.

4.4.3.2 Analysis of BAR Random Roadside Data

Following the BAR method of analyzing random roadside data, the following test records were deleted:

- vehicles with a gross vehicle weight rating (GVWR) greater than 8500 pounds;
- vehicles with aborted emission test results indicated by a blank in the emission results field ('TSTEMS'), and by a code of 1 in the aborted test field ('ABORT'); and
- vehicles sent to a referee station to confirm aborted tests. These are determined by a value of 9 in the 'ABORT' field and an indication that the referee station has not overridden the aborted test (a value of 'N' in the referee override field, 'REFOVRD').

The BAR data analysis excluded the most recent model year vehicles because BAR did not want to analyze vehicles that could never have been to an inspection and maintenance (I&M) test station. This analysis, however, did include the most recent model year vehicles.

The analysis was done for two sets of 1980 and later model year vehicles: all vehicle types in the data set, and California-certified, gasoline-powered passenger cars. This second set was extracted from all data by selecting only those records with the following values:

Variable	Value used for Selection
VHCLTYP	'P' (passenger vehicle)
FUELTYP	'G' (gasoline)
MDLYR	80 (model year 1980 and later)
CERTYP	'C' (California-certified)

The malperformance codes were those used in an ARB analysis[*] of the BAR data. It was considered a malperformance if the system variable had a value of ‘M’ (modified), ‘S’ (missing), ‘D’ defective, ‘F’ (fail), ‘T’ (tamper), ‘B’ (missing/nonconforming) or ‘C’ (disconnected/nonconforming). Most systems examined had a single data entry. Others required an analysis of two or more data fields. The following variables in the BAR data set were examined in this analysis:

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[*]Preliminary draft memo from Dilip Patel to Mark Carlock, "CALIMFAC Random Roadside Analysis,” received at Sierra Research December 20, 1993. Table 1 in that memo contains the malperformance codes; Table 3 contains the tampering, malmaintenance and malperformance rates for BAR 1990, 1991 and 1992 random roadside inspections for vehicle model year groups, Pre-1975, 1975-79 and 1980-Plus.

System	BAR Variable(s)	System Name
PCV	PCV & PCVFNCT	Positive Crankcase Ventilation
TAC	TAC	Thermostatic Air Cleaner
Evap	FEC	Fuel Evaporative Controls
CAT	CAT	Catalyst
EGR	EGR & EGRVLV	Exhaust Gas Recirculation
AIR	see below	Air Injection System
Spark	ISC	Ignition Spark Control
O2S	OXS	Oxygen Sensor

For 'EGR' and 'PCV', visual tests (variables EGR and PCV) and functional tests (variables EGRVLV and PCVFNCT) were analyzed; if either of these two tests failed, then the system was considered malperforming.

The other possible values stored in the BAR variables for the system components listed above are 'P' (pass), 'N' (not applicable), 'A' (aborted test) or missing/blank. Only vehicles with a 'P' for pass were considered passing vehicles; those vehicles with 'N', 'A' or missing values were not included in the analysis of that particular system. The total number of vehicles with a particular system, used to determine the malperformance rate, was calculated as the sum of the malperforming vehicles plus the passing vehicles for the system under consideration.

There are a series of variables related to the components of an air-injection system which require a separate analysis for this system. An initial variable, AIS, determines if the system is pulse air ('P'), not applicable ('N'), or an air pump ('A'). The total number of air injection systems was taken as the number of vehicles with a 'P' or an 'A' value in the AIS variable. The number of malperforming air injection systems was determined as the number of vehicles with any malperformance code (as listed above) in any of the following variables:

Variable	Component Name
AIP	Air Injection Pump
APB	Air Pump Belts
AIB	Air Injection Plumbing
ADV	Air Diverter Valve
ARV	Air Reed Valve
PAI	Pulse Air Injection

4.4.3.3 Comparison of ARB and BAR Data

The malperformance rates between ARB and BAR data were compared based on the ARB and BAR data sets developed as described above. Results of this comparison for all vehicles in the survey data are shown in Table 4-18. As the table shows, the percent failures in the ARB surveillance data are higher than those found in the BAR data for each emission control system. This is similar to the result found in the original development of the CALIMFAC model: the malperformance rates for ARB surveillance data on 1980 and later model year vehicles were higher than those calculated in the BAR roadside surveys.

Table 4-18
Component Malperformance Rates from ARB Surveillance Data and BAR Roadside Survey Data for 1980 and Later Model Year Vehicles
Data for All Vehicles in Survey

Emission Control System	ARB Surveillance Data			BAR Roadside Data		
	Total	Bad	% Bad	Total	Bad	% Bad
PCV Valves	1096	91	8.3%	4072	109	2.7%
Thermostatic Air Cleaner	1096	92	8.4%	2447	177	7.2%
Evaporative System	1096	83	7.6%	4070	44	1.1%
Catalyst	1096	128	11.7%	4050	27	0.7%
Exhaust Gas Recirculation	949	161	16.9%	3678	205	5.6%
Ignition System	1030	134	13.0%	4013	31	0.8%
Air Injection	592	61	10.3%	2338	68	2.9%
Oxygen Sensor	1035	442	42.7%	3651	9	0.2%

The same comparison is shown in Table 4-19, based on California-certified, gasoline-powered, passenger cars only. The BAR data generally show a very slight decrease in the malperformance rates as compared to the entire vehicle fleet, whereas the ARB surveillance data show both slight increases and decreases when compared to the entire vehicle fleet. Therefore, excluding federal vehicles and trucks does not significantly change the malperformance rates.

Table 4-19 Component Malperformance Rates from ARB Surveillance Data and BAR Roadside Survey Data for 1980 and Later Model Year Vehicles Data for California-Certified Passenger Cars Only						
Component	ARB Surveillance			BAR Roadside		
	Total	Bad	% Bad	Total	Bad	% Bad
PCV Valves	758	67	8.8%	2742	67	2.6%
Thermostatic Air Cleaner	758	61	8.0%	1489	94	6.3%
Evaporative System	758	56	7.4%	2742	13	0.5%
Catalyst	758	89	11.7%	2728	8	0.3%
Exhaust Gas Recirculation	643	117	18.2%	2447	115	5.0%
Ignition System	716	101	14.1%	2700	12	0.4%
Air Injection	397	45	11.3%	1439	27	1.9%
Oxygen Sensor	718	291	40.5%	2513	4	0.2%

4.4.3.4 Comparisons with Previous Analysis

Sierra staff compared BAR random roadside data from the 1992 survey with data from vehicles recruited for the last evaluation of the California I&M program (Project 2S91V1). Because the I&M data set included only vehicles that should have failed an I&M test, the BAR data were adjusted to include only that subset of vehicles. In addition, the numbers of vehicles used in the analysis of BAR data were adjusted so that both the BAR data set and the I&M data set would have the same distribution of vehicle model years.

The results of the earlier analysis found the defect rates to be similar for the CARB and BAR data sets except for missing catalysts and, to a smaller degree, for missing air-injection system components. Catalysts and air-pump hardware were missing at a higher rate in the BAR database as compared to the I&M database. In contrast to these results from the remote-sensing report, the analysis presented here found higher malperformance rates in the BAR data as compared to the ARB surveillance data. However, even if the malperformance rates in the BAR roadside and ARB surveillance data were the same, it would not be necessary to seek modifications to the ARB surveillance data to properly represent malperforming vehicles. The significant concern raised by the remote-sensing report is its conclusion that missing catalysts and air pump components occur at a higher rate in the BAR data as compared to the <u>I&M evaluation data</u>. In order to ensure that the <u>ARB surveillance data</u> were not under-representing missing catalyst and air-injection components, a separate analysis was made looking only at missing components. This comparison of missing catalysts and air-pump components was done for California-certified passenger cars using the same data sets that were used for the comparison shown in Table 4-17. The comparison of missing component rates is presented in Table 4-20. As the table shows, the rate for missing air-injection components is slightly higher in the BAR data, as compared to the ARB surveillance data. This is similar to the conclusion reached in the remote sensing report, but the difference between the BAR data and ARB surveillance data shown in Table 4-20 is not statistically significant.

Table 4-20
Missing Rates from ARB Surveillance Data and BAR Roadside Survey
1980 and Later Model Year California-Certified Passenger Cars

Component	Data	Total	Missing	Percent Missing		
				Obs.	LCL	UCL
Catalyst	ARB	758	1	0.1%	0.0%	0.4%
	BAR	2728	4	0.1%	0.0%	0.3%
Air Injection	ARB	397	3	0.8%	0.0%	1.6%
	BAR	1439	16	1.1%	0.6%	1.7%

Note: The entries in the percent missing column represent the observed percentage (obs) missing as well as the lower and upper 95% confidence limits (LCL and UCL).

These results compare not only the observed percent missing but also the upper and lower 95% confidence limits for the observed percentage. These confidence limits are computed from the cumulative binomial distribution. They represent the boundaries within which the missing rate is expected to fall, with 95% confidence, assuming the observed missing rate is the true missing rate for the population. Based on this comparison, there does not appear to be any statistically significant difference between the rate of missing catalysts or missing air pump components for the ARB surveillance and BAR random roadside data sets analyzed in this survey.

The difference between this conclusion and the one reached in the remote-sensing report, which found a significant difference in the rate for missing catalysts, may be due to the differences in the model years analyzed. The remote-sensing report analysis covered all model years, while the current analysis looks only at 1980 and later model years. When all model years are considered, the missing catalyst rate in the BAR database 0.5%, with a 95% confidence interval of 0.3% to 0.8%. The ARB data, for all model years, have a missing catalyst rate of 0.1%, with a confidence interval of 0.0% to 0.2%. Thus, when all model years are considered, the missing catalyst rate in the ARB surveillance data is higher than that in the BAR data and the difference is statistically significant. This is consistent with the conclusion in Sierra's CALIMFAC report that the ARB surveillance data underrepresented vehicle malperformance for pre-1980 model-year vehicles. This under-representation was corrected in the CALIMFAC database, which was used as the old master data set in this work.

4.4.4 Available EPA Data

The initial comparison of measured regime populations and CALIMFAC predictions discussed in the previous section showed that the largest disagreement was for high-mileage vehicles. Sierra examined various possible data sets that could be used to extend the ARB data and selected data used by EPA to correlate FTP and IM240 results as a good source of non-I&M data. As described below, this data set was corrected to a realistic pass-fail distribution for IM240 tests, and provided a source of late-model, non-I&M data that were not available in the ARB database.

During the development of MOBILE5, EPA compiled a very large database of vehicles (approximately 7,000 records) tested during the first two years of the Hammond, Indiana, I&M program (thus representing a non-I&M fleet of vehicles). Although the testing was performed over the IM240 cycle, EPA developed a set of correlation equations that "converted" the lane IM240 results (conducted on tank fuel) to an FTP/Indolene basis. The data used for this conversion were obtained from approximately 650 vehicles; 425 of these were a subset of the Hammond data, while 225 were tested at EPA's facilities in Ann Arbor. Because the data set was based on correlations, rather than actual FTP data, it was not used in the development of EMFAC2000. Instead, the FTP data collected for the correlation between FTP and IM240 results were used to bolster the existing non-I&M California data set. However, because the vehicles that received FTP tests were not randomly selected, the data first had to be weighted.

EPA staff has indicated that the vehicles recruited for FTP testing at the Hammond site were skewed toward higher emitting vehicles. In addition, the vehicles tested at the Ann Arbor site were pre-screened to eliminate tampered vehicles, and they likely under-represented the fraction of high emitters in an in-use, non-I&M fleet of vehicles. Thus, it was necessary to weight (i.e., add or subtract) vehicles in the 650-vehicle FTP data set so that it correctly represented the fraction of high-emitting vehicles in a non-I&M fleet. The FTP data set was weighted so that it had the same pass/fail rate for IM240 as the 7,000-car I&M fleet. Summarized below is the process used for this weighting.

- Pass rates were determined for technology-group and mileage-bin combinations in each fleet using IM240 cutpoints of 0.8 g/mi. HC, 15.0 g/mi. CO, and 2.0 g/mi. NOx (these are standard IM240 cutpoints used in many of EPA's analyses).

- EPA technology groups were used for this analysis because this was the only technology classification available in the I&M fleet; these were closed-loop multi-point fuel-injection (MPFI), throttle-body injection (TBI), and carburetted.

- Mileage bins consisted of 0-22,000, 22,001-45,000, 45,001-66,000, 66,001-85,000, and over 85,000 miles (as used in previous comparisons of CALIMFAC predictions and ARB data discussed in Section 2).

- The analysis was done for 1981 and later light-duty gas vehicles (LDVs); light-duty trucks were not considered.

- Because analyses were made on specific technology groups, no adjustment was made for the difference in the manufacturer fractions between the EPA data set and the California vehicle population.

4.4.4.1 Non-I&M IM240 Failure Rates from the Hammond Data

Vehicles were selected from the 7,000-vehicle I&M fleet to match the selection criterion outlined above. Additional selection criteria, consistent with EPA's selection of vehicles for developing MOBILE5 emission factors, were as follows:

1. vehicles that had odometer readings of 0 or of greater than 300,000 were deleted;
2. data collected on 14 test dates in March and April where the ambient temperature exceeded 75 F were deleted; and
3. only data for vehicles in an as-received condition were considered.

The number of vehicles in each technology group and mileage bin is summarized in Table 4-21, and the fraction of IM240 failures (for HC, CO, and NOx, independently) by technology group and mileage bin is given in Tables 4-22a to 4-22c. The fractions contained in Tables 4-22a to 4-22c was used as the basis for modifying the distribution of vehicles in the FTP database.

Table 4-21
Number of Vehicles in the Hammond IM240 Database
by Technology and Mileage Bin

Mileage Bin	Technology Group		
	MPFI	TBI	CARB
0-22K	818	448	130
22-45K	656	518	326
45-66K	372	410	436
66-85K	230	322	468
Over 85K	174	354	739

4.4.4.2 Converting Lab/Indolene IM240 Results to a Lane/Tank Fuel Basis

Because only IM240 scores based on Indolene were available for the Ann Arbor FTP data, it was not appropriate to use those values directly when establishing the fraction of IM240 failures. Vehicles tested at both the Hammond I&M lane and at a local lab had different IM240 results when comparing the lane results (on tank fuel) to the lab results on Indolene. EPA accounted for this difference prior to performing the IM240-to-FTP conversion.   Sierra accounted for this difference prior to segregating the Ann Arbor data according to the pass-fail rate, as described below.

The Hammond data for which both lane IM240 and lab IM240 (on Indolene) tests are available were used to develop adjustments to account for emissions differences between the lane and the lab. In general, this analysis indicated that vehicles with low Indolene/lab IM240 scores have much higher lane IM240 scores (i.e, up to 80% higher, depending upon pollutant), whereas those vehicles with relatively high IM240 scores (i.e., higher than the above cutpoints) have lane IM240 scores that more closely match the lab. Because of this, the data were segregated according to whether the IM240 cutpoints were met, and regressions were performed (i.e., lane/tank fuel versus lab/indolene). The regression results are summarized in Table 4-23.

Table 4-22a
HC Failure Rate in IM240 Database
by Technology and Mileage Bin

Mileage Bin	Technology Group		
	MPFI	TBI	CARB
0-22K	1.1%	2.0%	11.5%
22-45K	2.7%	6.0%	15.3%
45-66K	6.2%	12.4%	21.3%
66-85K	13.9%	21.4%	31.6%
Over 85K	27.0%	31.9%	44.8%

Table 4-22b
CO Failure Rate in IM240 Database
by Technology and Mileage Bin

Mileage Bin	Technology Group		
	MPFI	TBI	CARB
0-22K	1.0%	0.9%	13.1%
22-45K	2.6%	4.1%	15.6%
45-66K	4.6%	9.8%	18.6%
66-85K	11.7%	13.4%	29.3%
Over 85K	16.1%	16.4%	40.2%

Table 4-22c NOx Failure Rate in IM240 Database by Technology and Mileage Bin			
Mileage Bin	Technology Group		
	MPFI	TBI	CARB
0-22K	1.3%	2.0%	15.4%
22-45K	4.3%	6.0%	16.6%
45-66K	7.8%	12.4%	28.2%
66-85K	25.2%	21.4%	39.7%
Over 85K	37.4%	31.9%	47.4%

Several differences between Sierra's analysis and EPA's analysis are worth noting with respect to the fuel adjustments. First, only two "seasons" were considered in this analysis: summer, which was based on the five-month (May - September) volatility control period required by EPA's volatility rule; and winter, which consisted of the remaining months of the year. EPA considered four seasons in its analysis; however, the number of vehicles within each emitter group and season is fairly small in some cases, leading to questions of whether the effect is real or an artifact of a small sample size. Second, EPA did not use a regression approach in its analysis; it simply took the ratio of the mean emission level for each season and emitter group. Finally, the definition of emitter groups was slightly different. Sierra based emitter groups on the Indolene scores with the IM240 cutpoints listed above, while EPA's cutpoints were 1.64 g/mi. HC, 13.6 g/mi. CO, and 2.0 g/mi. NOx based on the lane scores. (The HC and CO cutpoints were considered together in EPA's analysis, i.e., a vehicle was considered a "high" if it failed either the HC <u>or</u> CO cutpoints.)

The regression coefficients in Table 4-23 were used to adjust the IM240 results for the Ann Arbor tests prior to using those results to determine the pass/fail status of the Ann Arbor vehicles. The net result of this procedure was a slight increase in the failure rate for the Ann Arbor vehicles.

Table 4-23 Summary of Fuel/Lane Correction Regression Analysis									
Month/ P-F Status	HC			CO			NOx		
	Int	Slp	R^2	Int	Slp	R^2	Int	Slp	R^2
May-Sep Pass Fail	 0.162 1.113	 1.060 0.514	 0.42 0.56	 3.04 12.14	 0.847 0.665	 0.33 0.54	 0.201 2.361	 1.210 0.508	 0.56 0.11
Oct-Apr Pass Fail	 0.014 0.995	 1.778 0.624	 0.44 0.62	 1.62 10.54	 1.183 0.734	 0.39 0.60	 0.285 0.449	 1.130 0.932	 0.61 0.72

Note: Intercept (Int) and slope (Slp) are for regression equations predicting the IM240 result (in g/mi.) on tank fuel in a lane test from corresponding IM240 result (also in g/mi.) on indolene in a laboratory test.

4.4.4.3 Adjustments to the FTP Database

As alluded to above, the FTP database was modified so that the IM240 pass-fail rates matched, as closely as possible, those observed in the complete Hammond database. This was done by comparing not only the overall pass-fail rate for the IM240 tests, but also the pass-fail rate for individual species. The comparisons of CALIMFAC predictions with recent ARB data in Section 2 indicated that the CALIMFAC predictions tended to produce slightly "cleaner" distributions than those actually observed for some technology groups and mileage bins. Because of this, the adjustment of the database was done by removing or adding clean vehicles. This kept all failing vehicles in the database while providing a representative pass-fail distribution.

A Monte Carlo selection technique was used in determining the vehicles to be eliminated or double-counted. This analysis was applied separately to each subfleet for a particular technology group and mileage bin combination. Each vehicle in the subfleet was considered, and the decision to retain, eliminate or double count a vehicle was made randomly. After each vehicle was considered, the IM240 pass rate for the resulting subfleet was computed for each species as well as the overall pass rate. This random analysis was repeated 50,000 times, and the subfleet which produced the minimum value in the square-difference in pass rate, defined as

$$\sum_{i=HC,Co,NOxandOverall}\left[(lane\ passrate)i-(FTP\,fleet\ \ pass\ rate)i\right] \qquad [4-3]$$

was used as the final subfleet from the EPA correlation data.

The result of the analysis for the different technology groups and mileage bins is shown in Tables 4-24a to 4-24d for overall results, HC, CO and NOx. The closest agreement is found in the overall failure rate for the adjusted fleet. Individual species results do not show as good agreement although there is an improvement for almost all technology/-mileage combinations. The closeness of the failure rates between the adjusted FTP fleet and the I&M fleet justifies the use of the adjusted FTP fleet data as a representative data set.

These additional data provided needed information on late-model non-I&M vehicles for use in determining regime sizes, mean emission rates of regimes, and regime growth functions. The fact that the vehicles were certified to federal standards rather than California standards was not a problem since the definition of regimes is based on the ratio of the actual emissions to the standard. However, because the EPA data set did not contain information on I&M repairs, which is needed for development of the normal regime, it could not be used in determing regime boundaries for "normal" vehicles.*

Table 4-24a

Overall Failure Rates in IM240 by Technology and Mileage Bin
Comparison of IM data, FTP data and adjusted FTP data

Mileage Bin	Fleet	Technology Group		
		MPFI	TBI	CARB
0-22K	I&M Fleet	3.0%	4.5%	24.6%
	Original FTP	0.0%	18.3%	0.0%
	Adjusted FTP	0.0%	10.4%	0.0%
22-45K	I&M Fleet	8.2%	12.2%	31.9%
	Original FTP	14.1%	27.3%	43.5%
	Adjusted FTP	7.6%	15.8%	29.2%
45-66K	I&M Fleet	13.4%	30.0%	46.3%

	Original FTP	22.7%	45.6%	62.5%
	Adjusted FTP	13.4%	29.5%	45.4%
66-85K	I&M Fleet	38.7%	45.0%	60.0%
	Original FTP	35.4%	50.0%	69.3%
	Adjusted FTP	37.0%	38.9%	57.4%
Over 85K	I&M Fleet	51.7%	56.5%	71.6%
	Original FTP	44.2%	61.1%	81.0%
	Adjusted FTP	51.5%	54.1%	68.1%
Adjustments to FTP fleet are set to get the best possible match for all pollutants and for overall failure rate.				

Table 4-24b

HC Failure Rates in IM240 by Technology and Mileage Bin
Comparison of IM data, FTP data and adjusted FTP data

Mileage Bin	Fleet	Technology Group		
		MPFI	TBI	CARB
0-22K	I&M Fleet	1.1%	2.0%	11.5%
	Original FTP	0.0%	6.3%	0.0%
	Adjusted FTP	0.0%	3.4%	0.0%
22-45K	I&M Fleet	2.7%	6.0%	15.3%
	Original FTP	9.4%	12.1%	25.0%
	Adjusted FTP	5.0%	7.0%	16.7%
45-66K	I&M Fleet	6.2%	12.4%	21.3%
	Original FTP	16.7%	29.5%	55.2%
	Adjusted FTP	9.4%	19.0%	39.4%
66-85K	I&M Fleet	13.9%	21.4%	31.6%

	Original FTP	20.8%	35.7%	43.6%
	Adjusted FTP	21.7%	27.8%	36.2%
Over 85K	I&M Fleet	27.0%	31.9%	44.8%
	Original FTP	27.1%	46.3%	60.4%
	Adjusted FTP	32.4%	41.0%	50.7%
Adjustments to FTP fleet are set to get the best possible match for all pollutants and for overall failure rate.				

Table 4-24c

CO Failure Rate in IM240 by Technology and Mileage Bin
Comparison of IM data, FTP data and adjusted FTP data

Mileage Bin	Fleet	Technology Group		
		MPFI	TBI	CARB
0-22K	I&M Fleet	1.0%	0.9%	13.1%
	Original FTP	0.0%	12.5%	0.0%
	Adjusted FTP	0.0%	6.9%	0.0%
22-45K	I&M Fleet	2.6%	4.1%	15.6%
	Original FTP	9.4%	15.1%	18.7%
	Adjusted FTP	5.0%	8.8%	12.5%
45-66K	I&M Fleet	4.6%	9.8%	18.6%
	Original FTP	15.1%	29.4%	45.8%
	Adjusted FTP	8.5%	20.0%	33.3%
66-85K	I&M Fleet	11.7%	13.4%	29.3%
	Original FTP	14.6%	33.3%	41.0%
	Adjusted FTP	15.2%	25.3%	34.0%
Over 85K	I&M Fleet	16.1%	16.4%	40.2%
	Original FTP	16.3%	24.1%	56.9%
	Adjusted FTP	18.1%	21.3%	47.2%

Adjustments to FTP fleet are set to get the best possible match for all pollutants and for overall failure rate.

Table 4-24d

NOx Failure Rates in IM240 by Technology and Mileage Bin
Comparison of IM data, FTP data and adjusted FTP data

Mileage Bin	Fleet	Technology Group		
		MPFI	TBI	CARB
0-22K	I&M Fleet	1.3%	3.1%	15.4%
	Original FTP	0.0%	12.5%	0.0%
	Adjusted FTP	0.0%	6.9%	0.0%
22-45K	I&M Fleet	4.2%	6.6%	16.6%
	Original FTP	4.7%	9.1%	31.3%
	Adjusted FTP	2.5%	5.3%	20.3%
45-66K	I&M Fleet	7.8%	19.5%	28.2%
	Original FTP	7.6%	16.2%	12.5%
	Adjusted FTP	4.3%	10.5%	9.1%
66-85K	I&M Fleet	25.2%	31.1%	39.7%
	Original FTP	12.5%	20.0%	43.6%
	Adjusted FTP	13.0%	14.8%	36.2%
Over 85K	I&M Fleet	37.4%	46.1%	47.4%
	Original FTP	25.6%	42.6%	44.2%
	Adjusted FTP	29.3%	37.7%	37.7%
Adjustments to FTP fleet are set to get the best possible match for all pollutants and for overall failure rate.				

The EPA data were used in the development of regime growth functions, which are discussed in the next section.